

A N
E S S A Y
O N
VISUAL GLASSES,
(Vulgarly called SPECTACLES)

Wherein it is shewn

From the Principles of OPTICS, and the
Nature of the EYE, that the common Struc-
ture of those Glasses is contrary to the Rules
of Art, to the Nature of Things, &c. and
very prejudicial to the EYES;

The Nature of VISION in the EYE explained,
and Glasses of a New Construction proposed.

The Whole illustrated by a large COPPER-PLATE-PRINT.

By B. MARTIN. *C*

The THIRD EDITION.

L O N D O N :

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[Price Six-pence.]

ESSAYS

VISUAL CLASSES

(Vocabulary called SPECULATIVES)

Wherein it is shown

from the Principles of OPTICS, and the
Nature of the EYE, that the common
view of these Objects is contrary to the Nature
of Light, and the Nature of Things, and
very prejudicial to the Eye.

The Nature of VISION is explained
and a new Method of seeing is proposed.

The following is a list of the

B. M. W. C. A.

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AN
E S S A Y
ON
VISUAL GLASSES, &c.

I Propose here to treat, in a brief Manner, not of the *Antiquity*, or *optical Theory* of *Spectacles*, but of their Use in assisting the Eye to see Objects distinctly, when the natural Form and Condition of it fail us; and to shew what is the necessary Construction or Disposition of those *artificial Glasses* for answering that *important Purpose* in the best Manner possible.

In the Course of Nature, most People are obliged to know by Experience the great and universal Use of SPECTACLES, both *convex* and *concave*, especially the former, concerning which Mr. *Molyneux* has this remarkable Passage: ————“ Were there no other Use of DIOPTRICS than that of Spectacles for defective Eyes, I should think the Advantage that Mankind received thereby inferior to no

other Benefit whatsoever, not absolutely requisite to the Support of Life. For as the Sight is the most noble and extensive of all our Senses, as we make the most frequent and constant Use of our Eyes in all the Actions and Concerns of human Life, surely that which relieves the Eyes when decayed, and supplies their Defects, rendering them useful when almost useless, must needs of all others be esteemed of the greatest Advantage. How melancholy is the Condition of him who only enjoys the Sight of what is immediately about him? With what Disadvantage is he engaged in most of the Concerns of human Life? *Reading* is to him troublesome; War more than ordinary dangerous; Trade and Commerce toilsome and unpleasant. And so likewise on the other hand, how forlorn would the *latter Part* of most Mens Lives prove, unless Spectacles were at hand to help their Eyes, and a little formed Piece of Glass supplied the Decays of Nature? The curious *Mechanic*, engaged in any Minute Work, could no longer follow his Trade than to the 50th or 60th Year of his Age. The *Scholar* no longer converse with his Books, or with an absent Friend in a Letter. All after would be melancholy Idleness, or he must content himself to use another Man's Eyes for every Line. Thus forlorn was the State of most old Men, and many young, before this admirable Invention, which on this very Account cannot be praised too highly."

This

This Invention being of so great a Concernment to Mankind in general, will certainly command their Attention to every Proposal for its Improvement; though it must be confessed there has scarcely any thing been done since they were first made that deserves to be so esteemed; perhaps no optic Instrument has been so little considered or altered since the first Construction, as *Spectacles*. The Maker or Seller is not to be charged with this Neglect; but the *Optician* (I mean a person skilled in the *Theory of Optics*) who, tho' he has condescended often to treat of the Subject, has never yet pointed out the best Method of constructing them for Use, nor even so much as taken notice of that very Form and Disposition of Glasses in this Instrument, which the *Science of Optics* points out, and makes necessary to their *Perfection*.

Among others, I myself have over-looked the Nature of this Instrument, till it fell into my Way to be more nearly interested in the Use of it. I before looked on it only as an useful Deduction from this Science, to others; but my own Eyes now beginning to require their Assistance, I began more particularly to consider them, and especially how and in what Manner they might be applied to the best Advantage for the Eyes, as I well knew the Manner in which Light affected those noble Organs.

I had not long reflected on the Subject, when I easily perceived the Errors of the common
Form;

Form ; and wondered much, how it was possible for Glasses in such frequent Use, to retain so long a Construction *quite contrary to the Laws of Optics*, and which, in the Course of a few Years, must prove so *very prejudicial to the Eyes*. I could no other Way account for it, but by considering that such Glasses, any-ways applied to the Eye, will assist the Sight ; and though the Construction were faulty enough, yet as that could not be immediately known by People who use them, it could be no Objection against them ; and not only so, but they must have *them* or none.

But since I was now to use them myself, I resolved at once to have a Pair as perfect as my Skill in Optics and the Form and Make of the Eye could direct me to construct ; and the Result was as follows.

I. I considered the two Glasses of *common Spectacles* were placed both in the *same Plane* ; and of Course their Axes were parallel to each other, and therefore could only be directed to Objects at a very *great Distance*, where we can see no Object with them at all.

II. That when we use Spectacles, the Axes of both Eyes are turned to the Object we view, and meet in a Point in it ; as in *reading, writing, working with a Needle, &c.* And consequently the Axes of the Eyes and of the Glasses are so far from coinciding (as they ought to do for *distinct Vision*) that they make a considerable Angle with each other.

III. That

III. That by this Means the *principal Pencil of Rays*, or those which belong to the Axes of the Glasses, which make the most perfect Part of the Image on the Bottom of the Eye, and which are necessary for perfect Vision: I say, all these Rays the Eyes are deprived of in the common Form of Spectacles, and only those Rays can enter the Eye from the Object we look at, which come on *one Side of the Glass* only, and are therefore *irregularly refracted* to the Eye, and so make the *Vision in Proportion imperfect*.

IV. I considered (and it is well known by Experience) the *Action of Light upon the Eye* tends gradually to *weaken it*; and that therefore no more of such an active Principle should be admitted into so delicate and fine a Structure as that of the Eye, than was quite necessary to illuminate the *Object*, and make it sufficiently visible. But the common Size of Spectacle-Glasses pours in upon the Eye-Ball three Times as much as is necessary for this Purpose; and therefore is very prejudicial to the Eye in this Respect, as in Time it makes them *weak and watry*.

V. But further, it is well known, that only a particular Quantity of Light is proper for *perfect and distinct Vision*; and that a greater or lesser Degree of it always impairs and confuses the Image and consequently the Vision of the Object by it: and for this Purpose, in *Microscopes, Telescopes, and other optical Instruments,*

ments, a Provision is made by proper Apertures and Diaphragms; but in *Spectacles*, where the Quantity of Light should be in the highest Degree regulated and adjusted, no Provision at all has been made; but the tender System of the Eye hath been left defenceless to the constant Attacks of the *superfluous and injurious Particles of Light*.

VI. Again, I considered that only those Rays of Light which fall near the Axes of the Glasses, can be regularly refracted to the Eye, and consequently only such can make the Image, or Vision of an Object in any Degree perfect: and therefore considering the unreasonable Area or Largeness of the Surface of common Spectacles, there must necessarily be a great Quantity of Light that will not only annoy the Image by Suffusion, but greatly vellelicate the Eye, and render the Image imperfect by an *irregular Refraction* from all the extreme Parts of the Glass.

VII. By the Doctrine of the *different Refrangibility* of Light we are taught by Sir Isaac Newton to understand that the Rays or Particles of Light are of very different Sizes or Magnitudes, and that therefore they must strike the Parts of the Eye with very different Forces; that from hence arise the various *Ideas of Colours*; that those Particles, which make the *red Colour*, are largest, as being least refrangible; and those which make the *violet Colour*, are most refrangible, and therefore of
the

the *smallest Size* ; consequently their Action on the Eye will be easiest, and of Course the *violet or purple coloured Glass* is the best of all for such Purposes, if such could be found that is good, but that is difficult to procure.

VIII. In the last Place it is to be observed, that the Image of an Object made by common compounded Light (as in *common Spectacles*) is not near so perfect as that made by one particular Sort of Rays ; and that therefore *Vision by a coloured Glass* is most of all perfect, and should be chose by every judicious Person, where an exquisite View of the Object is required.

These are the Principles on which this *new Construction of visual Glasses* depends. That they are real and important Facts, and founded in the Nature of Things, no one who has studied the *visual Science* can have the least Doubt of. But to illustrate such an interesting Affair, and make the whole of what I have said as clear as possible, I shall give a Representation of the Eye, the Spectacle-Glasses according to the *vulgar* and the *new Position*, and the Manner in which the Rays of Light proceed from an Object through both of them to the *Retina* in the Eye, which is the immediate *Organ of Light*. [See the Copper-Plate.]

A Description of the Eye.

The Structure of this noble Organ is not less wonderful than the Power and Wisdom by which it was formed. In its natural State,

B

every

every Part has the very Form and Office which the Laws of Optics require for the most perfect Vision of an Object, as will appear from the following Considerations.

1. Vision in the Eye is effected by Rays of Light reflecting through the Eye D E P Q [Fig. 1.] to the inner and hindermost Part, where the optic Nerve O P coming from the Brain, and entering the Eye at P, is expanded in a fine white Membrane over all the interior Part, as far as to E and D. On this Account 'tis necessary all the Parts of the Eye should be perfectly diaphanous or transparent, for the free Admission and perfect Refraction of the Rays of Light.

2. Since only a *convex Surface* will converge the Rays of Light to a Focus; the fore Part of the Eye D e E has that Figure, and consists of a strong pellucid Coat, which is called the *Cornea*, or *Horny-Coat* of the Eye, from its Resemblance to a Piece of clear *Horn*.

3. The Degree of Convexity or Roundness in the *Cornea* D e E must be such as will converge parallel Rays *a b*, *c d*, nicely to a Point on the *Retina* in the Bottom of the Eye, and of every distant Object AB, to perform a perfect Image I M on the said optic Nerve.

4. To give a requisite Convexity to the Eye, there is placed a Humour under the *Cornea*, which keeps it protuberant, and is called the *aqueous Humour*, from its Resemblance to *Water*.

5. If

5. If this Convexity of the Eye, or rather of the *Cornea*, be too great, as represented by the dotted Curve *D b d E*, then the Rays coming from the Object *A B*, will be converged to a Focus too soon, and form an Image *i m* short of the Retina; and in such a Case the Vision will be indistinct and confused. A Person having such Eyes is said to be *purblind*, or *short-sighted*; because he is obliged to hold Things very near, or at a short distance, to see them plainly.

6. When the *Cornea* becomes too flat, or has too little Convexity, as represented by the dotted *Cornea D b E*, then the Rays coming from distant Objects *A B* tend to a Point beyond the Bottom of the Eye, and form an Image *IM*, which upon the Retina *P Q* will be confused and imperfect, and the View of that Object will be so of course; and to such Eyes, the nearer an Object is, the more indistinct the Vision, as is too well known by Experience to most Persons in Years.

7. Next to the aqueous Humour we find a Part *D g f E*, which goes transversely across the Eye, and has, in the human Eye, a round Aperture *fg*, or Hole in the Middle, called the *Pupil*. This Part or Diaphragm (called by Anatomists, the *Uvea*) is destined to adjust a due Quantity of Light for perfect Vision; for, by a double System of muscular Fibres, we can make the Pupil one Half in Diameter less, and thereby exclude three-fourths of the Light,

when Objects are too bright and glaring ; and when they are remotely situated, and dark, we can make the Aperture or Pupil larger, to receive all the Light possible in such Cases.

8. Immediately behind the *Uvea* is situated the noble Part called the *crystalline Humour* FG, suspended by a Process, or Ring of muscular Fibres DF, GE ; by Means of which we have a Power of adjusting the focal Distance of the Eye, so as to make the Image perfect on the *Retina*, for every Distance of Objects. For the focal Distance of the Eye must necessarily be variable with the different Distances of Objects, and is thus wonderfully provided for by this curious Part ; it is in Form of a *Glass Lens*, one Side of which is more convex than the other ; it is contained in a fine Tunic or Coat, called the *Arachnoides* ; and when divested of this, it appears perfectly transparent, and clearer if possible than *crystal* itself : whence the Reason of its Name.

9. After this we find a large Quantity of what is usually called the *vitreous* or *glassy Humour*, filling all the hinder Part, and giving a Body to the Eye ; it fills all the Space DQPE, and is of a very transparent Substance, much resembling the *White of an Egg*.

10. These three Humours are of different Consistence, yet have all nearly the same Density and refractive Power ; they accurately provide for all the Circumstances of *distinct and perfect Vision*, making the Image so on the
optic

optic Nerve, expanded over all the Bottom of the Eye in a curious white Membrane, as before mentioned.

11. It is very observable, that by the Laws of Optics, no Image, I M, will be equally perfect in all its Parts, if formed on a *Plane* or *spherical Surface*; the Form, therefore, of the hinder Part of the Eye can be neither of these. And we are assured, by bare Inspection, that the Form Q P of the Fund or Bottom of the Eye is not spherical, as Q k P, but of a Figure between that and a Plane, that is *truly optical*, and fitted for defining the Image I M equally perfect in every Part

12. Another Thing remarkable in the Structure of the Eye, is, the Insertion of the optic Nerve O P, not in the Middle of the Bottom of the Eye, at k, but on one Side at P, for this good Reason, *that the Rays of Light which fall on the Part P, where the Nerve enters the Eye, are lost*, or the Object is not seen by such Rays; consequently, had the Nerve entered the Eye in the Middle at k, the Rays which make the Image in the greatest Perfection, had then been useless; and what is worse, we had seen a black Spot in such Objects as we looked most directly at; such wonderful Wisdom is displayed in the Structure of this curious Organ!

I shall take no Notice of the well-contrived Apparatus of Muscles by which the Eye is moveable in its Socket, and directed to any Object at Pleasure; it is sufficient to observe that

that it is every Way constructed to answer most compleatly all the Purposes of a *scioptric Ball and Socket*, or *Camera obscura* in Miniature. And as this Instrument of Vision is so very precious, and at the same Time liable to Defects that must be supplied by Art, it behoves every reasonable Man to expect the best Succours of this Kind, and to be more anxious, if possible, for the Safety and Preservation of the EYE, than any other Part of the Body; it being beyond Dispute the highest Performance of *divine Mechanism*, and the most important of all the *Organs of Sensation*.

And now let us see how this choice Part has been provided for by Artists; truly they have learned to know that a convex Glass will magnify, as they call it, an Object placed in the Focus, or some-where at a Distance from the Glass; and therefore, without more a-do, clap them upon old Peoples Noses, to view Objects with them in the best Manner they can. But this is far from being the Thing. It is not an indifferent Thing whether a Glass be applied to the Eye in this or that Manner; and every one who knows the *Philosophy of a Pair of Spectacles*, must understand, that as they succeed to the *Collyriums* or Eye-Salves, so they may with great Propriety still be reckoned the *Medicines of the Eyes*, and ought to be contrived and applied with the greatest Skill and Care.

This will more evidently appear from a Comparison

parison between the Form of *vulgar Spectacles*, and those which are here recommended of a new and philosophical Construction. To this End I have represented the two Eyes D X E, and D Y E, at the Distance they have in the Head, with the Spectacle-Glasses placed before them at the usual Distance also; the first of which, G H, is that of a *common Pair*, placed right before the Eye D X E; the other G H is one of the *new Form* placed in a proper Manner before the Eye D Y E. [See Fig. 2.]

Suppose both the Eyes were directed to an Object at a very great Distance, the Axes of the Eyes XX and YY, which are right Lines passing through the middle Points of the Pupil in each, will be parallel to each other as to Sense; and in this Case the Axes of the Eyes would coincide with the Axes of the Glasses; and it is in this Case only, *viz.* when the Axes of the Eye and Glass are the same, that distinct Vision can be made, or the Image of an Object be completely formed in the Eye. Now were the Glasses designed to view very distant Objects, the Glass G H would be in a proper Position. But this is not the Design of Spectacle-Glasses; and it is impossible to use them for any such Purposes; at least not *one in a Thousand* can use them to view distant Objects; and therefore the *Absurdity of the Position of Glasses in common Spectacles* is sufficiently evident.

For in the next Place, since only nigh Ob-
jects

jects can be viewed with convex Spectacles, and the Axes of the Eyes are always pointed towards them, in every such Case, it is plain, the Axes of the Glass and the Eye can be no longer coincident ; for let the Object near at Hand to be viewed be A , and both the Eyes turned directly to view it, as they always are ; then will the Axes of the Eyes $a A$ and $a A$ meet in that Object or Point A , but the Axis of the Glass $G H$ will still remain where it was, and be far from the Axis $A a$ of the Eye, and consequently there can be no direct or perfect Vision of the Point or Object A , by the Glass $G H$, in the common Position in Spectacles.

Now let us see how the Case stands with the other Eye, whose Axis $a A$ is directed to the Point A ; but so likewise is the Axis of the Glass $G H$; for the said Glass is now removed from the Situation $g b$ into another $G H$, which makes the Angle GCg , equal to aFY ; and consequently the Axes of the Eye and Glass do here coincide, and both become the right Line $a C A$, passing through the Center of the *Cornea* at F , and the Center of the Glass at C ; and therefore the Vision of the Object A , or its Image formed in the Eye at a , is as perfect as the Nature of Things can possibly admit of.

Again 'tis evident, the Pencil of Rays GAH , which flow from the Point A , and fall on the Glass $G H$ does, more than Half of it, after Refraction through the Glass, pass on one Side

the Eye at A; for even the Axis A C of this Pencil, which passes through the Center C of the Glass goes to one Side of the Eye at D, and consequently, that Half of the Pencil D A B, which lies beyond, must all fall off the Eye. And farther we observe, that of those Rays which do enter the Eye, by far the greatest Part are those which are irregularly refracted to it from the Sides of the Glass about H, and by which the Image of the Point A is rendered very indistinct and confused. The Reason of all which is, that, in this Case, the Axis A D of the Pencil of Rays, and the Axis A F of the Eye do not coincide, but make with each other the Angle D A F.

But with Respect to the other Eye at Y, the Case is quite altered; for the Glass G H is here placed in such a Manner that its Axis coincides with the Axis of the Eye, and both make one Line A F, passing through the Center C of the Glass G H of the Cornea; and therefore the Pencil of Rays, which form the Point A, fall upon this Glass, are by it equally and uniformly refracted to the Eye, and of Course must make the Image thereof at a on the Retina, as distinct and perfect as the Nature of Things will admit of. Hence then we make this Inference very justly, that in Respect of the *Position* of the Glasses, that in the common Way G H is not only *inartful*, but *injurious to Vision*; while that of the Glass G H, according to the new Form, is both consonant

to Reason, and what the *Laws of Optics* make necessary to view Objects in the best Manner.

In the last Place, let us but a little reflect on the Aperture or Dimensions of the Glasses in the usual Form, and we shall soon find that no Regard has been had to the Reason of Things, though obvious enough both from Nature and Art; for what Precept or Precedent do they find any where for pouring on the Eyes such a large, unnecessary, and hurtful Quantity of Light, as must be refracted through those large Glasses of *an Inch and Half in Diameter*, as most of them are very nearly? I say this Procedure is contrary to *Reason*, to *Nature*, and to *Art*.

It is in the first Place contrary to Reason; for every one knows that Light, by the inconceivable Activity of its Parts, is the natural Cause of the Disunion and Dissolution of the Parts and Contexture of Bodies; and in Proportion as they receive and detain more Light, they are more liable to be impaired and destroyed. Thus *black Bodies*, by imbibing great Quantities of Light, sooner become rotten, and are in every Respect more subject to Decay than *white ones*, which reflect most of the Light that fall on them. Too much Light from the Sun, when we directly behold it, immediately makes the Eye painful, and Vision, for some Time after, very much confused; and there is no Doubt to be made, but that the superfluous
Quantity

Quantity of Light constantly refracted and thrown upon the Eye-Balls by such large Glasses, must naturally tend to render them *weak and watery* by Degrees ; and this Effect we generally see attends the Use of common Spectacles. Besides, that Reason in all Cases forbids the Use of any Thing farther than is proper to answer the End proposed ; and since by all Experience it is known, that too much Light is prejudicial in forming the Image of Objects, it must be absurd, in the highest Degree, to admit of more than is sufficient or necessary for that Purpose in the Eye where Vision is required to be most of all perfect.

Again, it is *contrary to Nature* ; for we observe in the Eye a particular Provision made for adjusting a proper Quantity of Light for distinct Vision, in the Aperture of the Pupil ; and by this the Aperture of the Spectacle-Glasses should be limited ; that is, they should be so large as that the Pencil of Rays from any Point A, refracted through them, should be sufficient to fill the Area of the Pupil ; and if there be any more, as it can't enter the Pupil, it must do harm to the other Parts ; and therefore ought to be excluded. By this Means we shall find the Area of common Spectacle-Glasses near three times as large as it ought to be.

And, thirdly, it is a Practice *contrary to Art* ; for who does not, or ought not, to know, that in the Structure of a *Microscope*, *Telescope*, &c. it is absolutely necessary that

there should always be the strictest Regard to the Aperture of the Object-Glass? Since if that be more or less than just, the Instrument will be imperfect; one Degree of Light shews an Object distinct and fair, when another, greater or less, will quite spoil the View of it.

Now it is easy to observe [from *Fig. 3.*] That if the Spectacle-Glass *ABC* be an *Inch and Half Diameter*, as is nearly the common Size, and another Circle *abc* be described about the Center *three Fourths of an Inch in Diameter*, then the Light which falls on the Glass *ABC*, will be four Times as much as will fall on the Circle *abc*; but this Circle will admit of a sufficient *Field of View*, and the Light full enough for all Purposes; and therefore *three Parts in four* of the Light, which falls upon the Eye from common Glass *ABC* is unnecessary; and not only so, but very hurtful, and of Course ought to be excluded. And this I do by a large opaque Zone or Ring of black Horn *ooo*, as represented in the Figure. This *Annulus* of Horn is also a Safeguard to the Eye against all other foreign or extraneous Light that may come upon it Sideways. But though the Circle *abc* of three Fourths of an Inch be large enough in Reason; yet since *Custom*, the great *Tyrant against Reason*, generally has made People expect so great a Degree of Light, we have thought proper to indulge them with a circular Area of Light one whole Inch in Diameter, and therefore they ought

ought not to complain. Thus much for the Quantity of Light.

In the last Place, as to the *Quality of Light*, it is well known, as we before observed, that simple or homogeneal Light is much better on all Accounts, than the common compounded or heterogeneous Light, as will be more evident from Fig. 4. where A B C is a Prism, D E a Beam of the Sun's Light falling upon it at E, from whence it is refracted through it to the other Side at F, and from that Part the Rays now separated are again refracted through the Air to the several Parts between R and V, against the Side of a Room, all at different Distances from the Perpendicular F H to the Side of the Prism. The Part of the Beam which goes to R makes the *red Colour*; that at O an *orange Colour*, at Y a *yellow*, at G a *green*, at B a *blue*, at I an *indigo*, and at V a *violet Colour*.

Now since the Rays F R are the *least refracted*, they must be the largest in Magnitude, and strike the Eye with the greatest Force, and are therefore most prejudicial to it. On the other Hand, the Rays F V are most of all refracted, which proves that they are of the smallest Size, and consequently strike the Parts of the Eye with the least Force; and therefore those Rays, which are of a *violet Colour*, are most eligible for the Purposes of *Vision*, both as they form a *more distinct Image*, and as their Action is much easier to the Eye.

Hence

Hence the *vulgar Error* of supposing *green Rays* make the best Light for the Eye is apparent ; for blue and indigo Colours are preferable to them ; and so the yellow, orange, and red, are in order the worst Colours of Light. Upon the Whole then we learn, both from Nature and Art, that they who would see or view Objects with the greatest Ease and Perfection, must use *visual Glasses* of the Construction and Colour above described. And a *Word to the Wise is enough*. But to others, the Eloquence of *Cicero*, joined with the Sublime of *Longinus*, would be lost. I have done what I can, in a small Compass, to open their Eyes, and to make them see in the best Manner, and according to Art ; but if Custom and Prejudice be more prevalent, let them chuse : *Si Populus vult decipi, decipiatur*.

Since I have proposed these *visual Glasses*, I have the Pleasure to find they are greatly approved of, and very well received, even beyond my Expectation. The Objections against them are few, and scarce worth mentioning.—One has said, *he can't see to read better in these, or find them easier to his Eyes, than common Spectacles*. That is undoubtedly true, and who would expect a sensible Difference immediately, if it be considered, that the Eye is so admirably formed, that it can view an Object tolerably well by Rays of Light refracted upon it in the worst Manner possible ? But can this be a Reason why Vision

sion should not be performed in the best Manner? But farther—*they do not find the Light hurt the Eye in one Glass more than in the other.*—Very true; nor do they see the *Stone* grow hollow by the dripping of *Water* in Half an Hour; yet this will be the Case in Time; and every wise Man looks to the Consequences in the Use of Things of so interesting a Nature.

Another has objected—that *these visual Glasses have an uncouth Look, sit askew upon their Nose, &c.* To which, if any Answer be due, I can only say, that, to a judicious Person, whatever is best, has the best Look; and they sit most properly in that Position which Nature has directed. But Sir Francis—— has a numerous Family, and when their Eyes require Assistance, 'tis natural to expect they should chuse *Spectacles*, rather than *visual Glasses*, especially if they have the Privilege of paying a very great Price for them.

I shall take no notice of the low Arts that have been practised to vilify this Invention; they who pretend that I have stolen it from *some old Author*, would do well to produce that Author, lest their *Veracity* and *Honour* should be called to question; or, what perhaps they would have still less disputed, their *Wit*, in not securing to themselves what they think, in my Hands, will do them such mighty Harm.

To those who charge me with *under selling them*, I answer, I know not their Prices; and
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as I have a sufficient Profit on what I sell, it proves they have taken *too much* ; for which the Public must think themselves greatly obliged to their Candour and Gratitude.

Lastly, those who weakly insinuate that I *imitate them*, must be told, that they publish an Untruth ; I have no Reason for doing that ; their Inventions are too mean and unscientific to deserve my Notice : I sell little besides what I have contrived myself ; and my Instruments will recommend themselves to all Judges of Science ; and not only that, but save the Public *Cent. per Cent.* in buying. I have only one Favour to ask of those worthy Gentlemen, and that is, that, since they have taken so much Pains to depreciate my Inventions, they will act consistently with themselves, and *not imitate them*.

Let them, who know nothing of *Optics*, make *Spectacles* ; and those, who profess not to use their Reason, buy them : I shall always find a Demand for VISUAL GLASSES ; and the generous and judicious Part of Mankind will readily distinguish between the *Author* of any useful Invention, and those who basely *pirate the same*.

DIREC.

D I R E C T I O N S

For the Use of the

GENERAL APPARATUS

OF

OPTICAL INSTRUMENTS.

I. THE COMPOUND POCKET MICROSCOPE

must be held in a perpendicular Manner, and the Object to be viewed is to be laid on the concave Glass below ; and then the inner Part moved gently up or down, will exhibit a clear and pleasant View of the Object ; if it be a transparent Object, the Light will be reflected from the Looking-Glass below, and shew it very plainly. A *Tadpole*, or small Fish, is to be placed in the glass Tube for viewing the Circulation of the Blood in the Tail, Fins, &c. Very small living Objects are to be put into the smallest Tube to be viewed ; or they may be placed in the Concave with a Piece of plain Glass over them to confine, yet not bruise them. In the same Glass you also put a Drop or two of Water, Vinegar, &c. to view the *Antmalculæ* in them. For viewing the larger sort of small Objects you screw off the upper Part of the Microscope, and holding the Object just under it, or before it, they appear very distinct and beautiful. Note, *The Objects to be viewed should always be held in the Sun, or in*

a good Sky-Light; they may be placed on long Slips of Glass with a little Gum-Water, and be laid for Use.

II. *WILSON'S* MICROSCOPE is used to view transparent Objects, placed between the Talks in the Ivory Sliders, which it magnifies to a great Degree, and with wonderful Perspicuity. The Circulation of the Blood, *Animalculæ* in Fluids, &c. are here seen to the utmost Advantage in the glass Tube, placed between the brass Plates of the Microscope. The Sliders, or Tubes, being placed between those Plates, you turn the Screw below, one Way or the other, till the Object appears very plain, which it will always do, if you hold up the Instrument towards the Sky or Candle. Note, *You must turn the Screw, while your Eye is viewing the Object.*

III. The SCIOPTRIC BALL and SOCKET is placed, by Screws or otherwise, in a Hole of the Window-Shutter, in a Room made quite dark. Into this Ball you screw the Piece containing a Glass only, which will make a curious Picture or Landscape of all Objects before the Window, or on any Side, by turning the Ball with the Glass towards them. The Colours are in the highest Perfection, the Motions all natural, and the perspective Scenery just.

IV. The SOLAR MICROSCOPE by Refraction, is the Part to which *Wilson's* is screwed on; at the large End it is screwed into the Scioptric-Ball, and there is placed a Glass to illuminate the Object (as before) placed between the brass Plates, in *Wilson's* Part; by Means of the Drawer, you may bring the Object near to the Focus of the illuminating Glass, and thereby make the Light on the Object as strong as you please; then the Tube, being placed in such a Position as to receive the Sun's Light through it, by moving the Screw of *Wilson's* Part, you will find it easy to make the Image very perfect on the Paper-Screen, or white linen Cloth, placed perpendicular to the Axis of the Microscope. At ten Feet Distance the Object will be magnified upwards of a thousand Times in Length and Breadth, and more than a million of Times in Surface. And in this Way

the solar Microscope the Image is much more luminous and strong than in the common Way. *Note*, when living Objects, as Mites, &c. are to be viewed, they must not be brought too near the Focus of the Glass, lest you kill them with Heat.

V. The POCKET TELESCOPE magnifies about ten Times, or brings every Object so much nearer to the Eye in Appearance, and therefore the Surface of Objects will be an hundred Times larger seen through such a Telescope, than when viewed by the naked Eye. There are proper Marks on the Drawers to set them by; and that next the Eye must be moved a little backward or forward till you find the true Focus, or most distinct Appearance of the Object.

VI. The SOLAR TELESCOPE is the same Pocket-Telescope, adapted to the Ball and Socket, by Means of a Piece of Wood, which on one Side is screwed into the Ball, and on the other it receives the Object-End of the Telescope, when the brass Cap is screwed off; the Telescope, being thus fitted on, is to be placed in the Direction of the Sun-beams, and they will pass through it, and then, being held steady with one Hand you move the Drawer at the other End a little in or out with the other, and you will soon find the Place where the Sun's Face or Image will be made very distinct on the Sheet of white Paper held perpendicular to the Rays, and will be larger in Proportion as the Paper is farther removed from the Instrument. In this Manner you will easily view the *Maculae*, or Solar-Spots, the Clouds passing over the Sun in a most beautiful Manner, the Moon passing over the Sun in a Solar-Eclipse, the *Transits* of *Mercury* and *Venus* over the Sun's Disk, and many other curious Purposes may be answered thereby. *Note*, Before you screw it on to the Ball, the Drawers must be all set to their Marks or Circles, as when you use it in the common Way.

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